Preliminary Impacts of PACS Technology on Radiology Department Operations

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ABSTRACT

The potential benefits of digital imaging to clinical operations focuses on both quantitative and qualitative improvements. In the future it is postulated that it will totally replace analog imaging, creating the 'filmless' Radiology department. Although this could result in dramatic savings in film costs, realization of this scenario will require continued improvements in the performance and cost of component technologies, acceptance by the medical and legal communities of the reliability of the medium, and changes in the practice and process of radiology.

Baltimore VAMC has recently become one of the truly 'filmless' radiology departments through use of a leading commercial Picture Archiving and Communications System (PACS) and DHCP's Digital Imaging System. This document outlines the results of a preliminary assessment of PACS technology as it is installed at Baltimore, and its impact on operations.

INTRODUCTION

Archiving diagnostic radiology films and reports presents a significant challenge to hospitals and healthcare institutions. In a typical radiology department, archives hold all diagnostic patient images taken over the past several years. Older films -- those up to seven years old -- are usually kept elsewhere to satisfy legal requirements. Over the course of a year it is not uncommon to conduct 24,000 such examinations, requiring the unique identification and storage of upwards of a quarter million patient films.

Medical images are central to the careful diagnosis and successful treatment of patients. Retrieval and use of these films is one of the greatest logistical problems faced by hospitals. Because of the importance of these films and competition for them among different care providers within the institution, it is not unusual for radiology films to be missing. This results in tremendous frustration among clinical staff, and leads to highly paid clinicians searching for films both within and outside the Radiology department.

These and other problems associated with management of film archives routinely impede the timeliness of patient care. Not only do they present logistical hurdles, they can also impact the quality of patient care itself by requiring that studies be repeated -- needlessly irradiating the patient a second time -- or lack of consideration of prior medical history in formulating a diagnosis. In response to these challenges, Picture Archiving and Communication Systems (PACS) are being developed to expedite the retrieval and simultaneous use of medical images, providing functionality to scan, index, and compress data.

This study outlines the results of a preliminary assessment of this technology conducted at the Baltimore VAMC as part of VA's HOST program. This institution has installed a state-of-the-art digital imaging system using the DHCP Digital Imaging System and a commercial PACS system. New capabilities provided by these systems are being used to implement one of the first truly filmless radiology departments now on record.

Overview of PACS Technology

PACS evolved as clinicians sought ways to improve access to medical images. Consequently, the design of these systems emphasizes the use of networks and distributed processing to enable comprehensive access to images stored centrally. Other considerations that have helped shape development of the technology focus on new developments in radiological devices themselves. In the past decade, CT, MRI, and ultrasound scanners have all used advanced technology to improve the quality of medical images taken of soft tissues. All of these devices record images digitally, and account for roughly 20% of the volume of a typical hospital. X-rays, a technology dating from the turn of the century, continue to record images using analog techniques. These images must be concerted to a digital format before they can be used in a PACS. These systems have only become technically feasible due to

0195-4210/94/$5.00

Study Question	Indicators
Digital Imaging improves patient care ...	... by increasing the availability of images ... by increasing the accessibility of images ... by enabling better diagnosis ... by enabling physicians to spend more time with patients
Improves Service Levels...	... by reducing processing time ... by reducing reading time
Facilitates BVAMC's Educational Role...	... by better enabling 'curbside consults'

Figure 1. Study Hypotheses

improvements of several component technologies over the past several years.

Among the most important performance characteristics of imaging systems is the resolution at which images are stored and displayed. Analog technologies record 8 - 12 bits per pixel, using a multi-tone gray scale to map images. In converting these to digital format, the image is divided into a matrix of pixels. The depth of data recorded for each pixel can vary from 12 to bits. The quality of an image is enhanced as the size of the matrix is increased, increasing the number of pixels, and hence, the resolution of the image. These two dimensions -- the size of the matrix and the number of bits per pixel -- define the diagnostic quality of images. Although there is no agreement as to what precision is needed to routinely ensure ease and accuracy of diagnosis, these criteria are generally used to rank the utility of PACS.

Note that these criteria apply only to analog images such as chest X-rays. CT, MRI, and ultrasound images are filmed and recorded digitally at 8 bits per pixel. However, these types of images make up less than 20% of the workload of a radiology department.

METHODOLOGY

Initial research developed an understanding of the technology and its use and acceptance in the commercial marketplace. This pointed to several macro-level impacts that could be expected from introduction of digital imaging. From this basis, interviews with radiology staff and physicians identified several specific hypotheses to be addressed in a comprehensive assessment of the technology. For each hypothesis outlined in Figure 1, both measurable and subjective indicators were agreed upon.

Over the course of the ten week project a structured task plan was used to coordinate activities that included interviews, shadowing physicians and staff, and formulating analyses that developed each of these perspectives.

FINDINGS

At the outset of the assessment it was agreed to measure the success of digital imaging technology by collecting data concerning several specific hypotheses.

Digital Imaging Improves Patient Care

... by increasing the availability of images

Evidence collected suggests that in a manual environment there is significant competition for patient films. The most immediate and credible measure of this competition is the 'hit rate' or the probability of finding a desired film. At BVAMC this was approximately 90%. This competition can also be gauged by the demand for images. The frequency of requests for archival images was 37 minutes during the course of an average workday.

Competition for films will be wholly eliminated by digital imaging. This will be the single most important contribution the technology makes in improving clinical practice.

... by increasing the accessibility of images

Whereas availability refers to the ability to locate films, accessibility addresses the issue of where they can be retrieved. In current practice images are routinely interpreted in a wide variety of locations

close to the point of care. Light boxes are situated strategically throughout the clinics, inpatient wards, and ORS.

Once the PACS system is fully operational there will be 53 DHCP digital imaging terminals throughout the house, and an additional 20+ commercial terminals. This will not be a significant change from the status quo.

... by enabling better diagnosis

There are many dimensions to this issue, all relate to defining the improvements possible by use of the technology.

From a film quality perspective, digital imaging provides the same precision as analog techniques for typical computed radiology images. Some downsizing is required. However, the full implications of this reduction is not well understood from a clinical perspective, and the literature itself does not draw any definitive conclusions.

The second perspective is that of the timeliness of diagnosis. The most telling measure of this is the time required for an outpatient film to be carried back to radiology to be read. This delay in formal diagnosis will be eliminated through use of digital imaging technology. Another measure of this is the turnaround time for portable exams. The study conducted demonstrated that it took less than one hour to respond to a portable request, and an additional half hour before it was first read. This second component could be significantly reduced through use of digital imaging technology.

The last perspective is that of the tools available to clinicians in reviewing images. In a manual environment, the only tools commonly used were the hot box and the magnifying glass. In the computer environment these tools are much more sophisticated, and are augmented by others that have no counterpart in current practice.

In summary, digital imaging will promote accurate, timely diagnosis. Moreover, it will provide clinicians with new analytical tools that could lead to improvements in the practice of care.

... by enabling physicians to spend more time with patients

Physicians universally agree that full implementation of digital imaging will allow them to deliver more direct patient care. As evidence of this, every 37 minutes during the course of a weekday a physician presents at radiology looking for a film. The time in vested in each of these episodes directly detracts from providing care.

Digital Imaging Improves Service Levels

The second premise is that digital imaging will make significant improvements in the level of services provided by radiology.

... by reducing processing time

Use of phosphorus plate technology will not yield any improvements over current practice. In a manual regimen image processing takes on the order of 90 seconds. This will continue to be true using the phosphorus plate processor.

... by reducing reading time

The time invested in reading images is the product of a variety of factors, only a few of which will be influenced by use of digital imaging. Ongoing research is being conducted to determine the full impact of the technology.

Digital Imaging Facilitates BVAMC's Education Role

The third premise is that introduction of digital imaging will significantly enhance BVAMC's educational capabilities.

... by better enabling consults

In an operating environment based on use of films, consults are necessarily face-to-face. Consults are not rare, but the time required to leave the ward and go to radiology do make them relatively infrequent from a physician's perspective. Introduction of simultaneous review of images will enable a true interactive consultation from anywhere in the facility.

DISCUSSION

Adoption of computer technology has profound implications for operations. Improvements in computer support have a direct impact on the process and practice of care, which in turn begin to transform organizational roles and structure.

Impacts on Practice

Widespread adoption of digital imaging will engender practice improvements and innovations that could significantly improve patient care. A number of specific innovations can be expected.

Radiologists will play a larger role in clinical decision making. This will be manifest in the frequency of consultations. For the first time, digital imaging will make it possible for the full integration of Radiologists in the real-time interpretation of images. Manual systems do not permit this because of the logistical problems of finding films, and the requirement for physicians and Radiologists to meet and discuss images. As physicians become familiar with the system and its capabilities, it can be expected that on-line consultations over the phone in which images are simultaneously viewed from remote locations will increase.

The routine of reading films will incorporate use of tools provided by PACS technologies. Both commercial and DHCP systems offer diagnostic tools superior to those available in a manual operating environment. As Radiologists and others that make diagnoses become familiar with these tools, a new regimen for interpreting images may arise that routinely takes advantage of these capabilities.

The impact of these practice changes will be to enhance the role of Radiologists by making their skills more widely available and by making their diagnoses more comprehensive.

Impacts on Process

As production in radiology shifts from a film-based to an image-based process, procedures required to support production can be expected to change. For example, real-time interpretation and diagnosis could evolve. In a manual environment there is a significant delay between ordering a film and receiving a radiology report. Often the most significant delay is that between completing an exam and having a Radiologist make an interpretation.

The key cause of both these types of delays is that patient films must be physically carried from one location to the next. Digital imaging eliminates this by providing images instantaneously. This new capability will facilitate the evolution of real-time reading, where instead of interpreting images in batches, Radiologists may be able to keep up with production as it occurs. Real-time reading will no doubt require reassessment of basic support systems and procedures.

Another example is the elimination of most archive activities. Handling films as they are processed, routed, read, archived, and retrieved currently consumes a majority of the time and attention of radiology staff. Implementation of digital imaging would remove most of these requirements. Once processed, images will be wholly automated.

The value of these changes will be to reduce inherent complexity and thus streamline operations, reducing most measures of radiology turnaround time.

Impacts on Jobs

The reduction in process complexity enabled by digital imaging will necessarily change the roles -- the jobs -- of individuals employed in the Radiology Service. A number of specific changes can be anticipated.

Labor investments now made in archiving activities can be redeployed. As the department transitions to a filmless environment, it is envisioned that archived films will be converted to digital format when a patient presents for treatment. This will most likely be done by the Film Library staff. Consequently, the role of these individuals will shift from that of managing files to inputting images using a digital scanner.

Responsibilities for systems management can be added. Effective use of PACS will require the active participation of mangers or supervisors in managing the system and its data.

The impact of these changes will be to change the skill mix of the Radiology staff. Depending on the balance achieved, this could increase labor costs in the Service.

Impacts on Organization

The last dimension of operations that will be impacted by use of digital imaging is that of organizational structure. The premise is that as jobs evolve along new lines, the structure of the department will also change.

It is difficult to guess how this evolution will take place, but its general direction is clear -- to reorient radiology from a 'factory for films' to a more clinical focus. The rationale for this is that use of film erects barriers that distance radiology from direct patient

care. These barriers include the availability and access of film and the manual production systems that have grown up around it. As digital imaging eliminates the use of film these barriers will fall. This will enable Radiologists, Radiographers -- and the services they provide -- to be better integrated in the mainstream of patient care activities.

In summary, use of digital imaging will create efficiencies in the practice of radiology and in the production processes that support it. Primary benefits will be the elimination of problems associated with film handling and management. Secondary benefits touching on jobs and organizational structure will not be realized without concomitant practice and process changes.

ACKNOWLEDGEMENTS

This work was funded by the Medical Information Resources Management Office, Department of Veterans Affairs as part of the HOST program.

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